DOCUMENT RESUME

ED 408 168 SE 060 251

AUTHOR Goodell, Joanne E. Tims; Parker, Lesley H.
TITLE Operationalizing Equity through School Reform in Mathematics.
SPONS AGENCY National Science Foundation, Arlington, VA.
PUB DATE Mar 97
NOTE 25p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997).
CONTRACT OSR-92500
PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Classroom Environment; Concept Formation; *Cultural Influences; Curriculum Development; *Educational Change; Elementary Secondary Education; *Equal Education; Foreign Countries; *Mathematics Instruction; Program Evaluation; Sex Differences
IDENTIFIERS Australia

ABSTRACT

The purpose of this paper is to explore the links between equity and reform in mathematics education. An overview of the research into problems associated with equity and mathematics education is presented, followed by an overview of the types of initiatives that have been employed to overcome the problems. A framework for viewing the problems and solutions is discussed followed by an operational definition of equity in the mathematics classroom. A review of two large-scale reform efforts in mathematics is presented and the data derived from monitoring these reform efforts forms the basis for this paper. A wide range of quantitative and qualitative data from the reform monitoring efforts is employed to examine the technical, cultural, political, and moral dimensions of enacting equity in reform. Contains 65 references. (Author/DDR)

OPERATIONALIZING EQUITY THROUGH SCHOOL REFORM IN MATHEMATICS

Joanne E. Tims Goodell and Lesley H. Parker

Curtin University of Technology

GPO Box U 1987

Perth WA 6001

Australia

email <rgoodell@alpha2.curtin.edu.au>

Paper presented at the Annual Meeting of the

American Educational Research Association

March 24-28, 1997, Chicago

The preparation of this paper was sponsored in part by the National Science Foundation, Grant # OSR-92500 (J. B. Kahle and K. G. Wilson, Co-Principal Investigators). The opinions expressed are those of the authors and do not necessarily reflect the position of NSF.

ABSTRACT

The purpose of this paper is to explore the links between equity and reform in mathematics education. An overview of the research into problems associated with equity and mathematics education is presented, followed by an overview of the types of initiatives that have tried to overcome the problems. A framework for viewing the problems and solutions is then presented, followed by an operational definition of equity in the mathematics classroom. We then review two large-scale reform efforts in mathematics which we have been involved with monitoring. From a wide range of quantitative and qualitative data gathered during the monitoring of these reforms, we examine the technical, cultural, political and moral dimensions of enacting equity in reform.

OPERATIONALIZING EQUITY THROUGH SCHOOL REFORM IN MATHEMATICS

JOANNE E. TIMS GOODELL AND LESLEY H. PARKER
TEACHING LEARNING GROUP
CURTIN UNIVERSITY OF TECHNOLOGY

INTRODUCTION

The purpose of this paper is to explore the links between equity and reform in mathematics education. Concerns about equity in mathematics education have been expressed in the literature for at least 30 years. The main focus of these concerns has been gender equity, although in more recent years attention has also been paid to inequitable outcomes associated with cultural, ethnic, language and other minority groups. In this paper, we focus on two large-scale State-wide mathematics education reforms implemented in the USA and Australia linking them to the Willis (1996) perspectives on "disadvantage and the mathematics curriculum". We summarise the findings of the large range of quantitative and qualitative data gathered during the monitoring of these reforms, and then interpret these findings in the context of Rossman's (1993)framework, distilling, from our analysis, the essential components of a curriculum reform premised on equity.

EQUITY CONCERNS

Equity concerns in mathematics education have most often been expressed in terms of differences in performance or participation of certain groups of students. International studies of mathematics achievement have highlighted differences in performance of males and females on multiple-choice tests. For example, the International Association for the Evaluation of Educational Achievement (IEA) conducted the First International Mathematics Study (FIMS) in 1964 (Husen, 1967), involving twelve countries. After all countries were combined at all age groups, and allowances were made for differing levels of mathematics instruction, the study found differences in favour of males. These differences increased with age, but varied across countries.

Similarly, the Second International Mathematics Study (SIMS) involving twenty countries, conducted between 1980 and 1982 (Robitaille & Garden, 1989) ,

Tims Goodell, J.E. and Parker, L.H. (1997) *Operationalizing equity through school reform in mathematics.*
Paper presented at the Annual Meeting of the American Educational Research Association, Chicago.

also used multiple-choice items (some of the same items as the FIMS). It was found that, at age thirteen, females outperformed males in four countries, with the reverse being true in nine other countries.

While concern continued to be expressed through the early 1980's, many reviews since that time have found gender differences in achievement to be declining. Meta-analyses conducted by Linn and Hyde (1989) showed that

(i) gender differences in spatial ability were heterogeneous and declining;
(ii) gender differences in quantitative ability were declining for most measures but remained on the SAT-M;
(iii) gender differences in confidence and interest in mathematics in high-school students were large and had remained so for a number of years, however no such differences were evident in the elementary years;
(iv) gender differences in cognitive processes often reflected differences in course enrolment and training; and
(v) gender differences in height, physical strength, career access, and earning power were much larger and were more stable than gender differences in cognitive and psycho-social tasks.

More recently, Frost, Hyde and Fennema (1994) reported meta analyses on 100 studies of gender differences in mathematics performance and 70 studies of gender differences in mathematics-related attitudes and affect. They noted small non-significant effect sizes favouring males for mathematics performance. Females' attitudes and affect were more negative, but again the effect sizes were small and non-significant. Males were found to hold a much more stereotyped attitude of math as a male domain.

Despite the closing of the gender gap in achievement, gender differences in participation in higher-level mathematics have persisted around the world (American Association of University Women, 1992; Burton, 1992; 1995; Eccles, 1989; Fennema, 1990; Leder, 1990a). Enrolment patterns in secondary school mathematics courses have been well documented in Australia (Australia. Department of Employment Education and Training (DEET), 1991; Dekkers, deLaeter, & Malone, 1991; Parker, 1992b; Parker, Thomson, & Tims, 1993). Generally in Australia, it is clear that as soon as the study of mathematics is no longer compulsory (usually at Grade 11), females choose not to enrol in the more challenging mathematics subjects. Similar patterns and concerns are evident around the world (Clewell & Ginorio, 1996; Equity in Mathematics Education, 1990; Fennema, Wolleat, Pedro, & Becker, 1981; Gaskell, McLaren, Oberg, & Eyre,

1993; Grevholm, 1996; Leder, 1992; Linn & Kessel, 1995; Niederdrenk-Felgner, 1996).

EQUITY-BASED REFORMS

Varying Perspectives on Reform

In order to address inequitable outcomes in mathematics education, various equity-based reforms have been tried with varying degrees of success. Willis (1996) suggested that the goals of equity-based reform vary according to the ideology or perspective of the reformers. After a long association with equity-based reforms at many levels—the individual, school and policy level—Willis developed a framework for reviewing a range of issues associated with addressing gender differences in mathematics education. Her association with people who held many different viewpoints about what constitutes equity-based reform led her to conceptualise a framework for viewing "disadvantage and the mathematics curriculum". Depending upon the particular viewpoint of the individual (or group), different solutions were offered for the same problem, namely that of inequitable outcomes in mathematics education. Because of its specific relevance to mathematics education, this framework provided an appropriate initial conceptual model for the study reported on in this paper.

Willis described four different perspectives. For each perspective she outlined how the mathematics curriculum is viewed, who the problem of disadvantage lies with, what the solution could be and what the educational task is. The first perspective, which Willis names "Remedial", can be related to Kenway and Modra's (1992) view of liberal feminism in that it is concerned with how much access to the curriculum girls and minority groups have. Documentation of the access and success of women and minorities is the main focus of this research, and initiatives are designed to redress these inequities through improving access and boosting success. The second perspective is called "Non-Discriminatory" and can be thought of as coming from a radical-feminist point of view, one that is concerned with promoting the positive aspects of feminine experiences. It seeks to encompass women's as well as men's experiences. Initiatives from this perspective focus on broadening the range of pedagogical and assessment practices used in the mathematics classroom, so that the interests and experiences of all groups of students are considered. The third Willis perspective is called "Inclusive", and is loosely related to both socialist-feminist and radical-feminist perspectives. The Inclusive perspective is concerned with reforming the mathematics curriculum so that it is more

reflective of the range of experiences and interests of the diverse student body in today's classrooms. The fourth Willis perspective, "Socially Critical", is related to socialist-feminist concerns that seek to expose the social structures and discourses that position women and minorities outside traditional mathematics. The Socially Critical perspective provides a better basis for challenging the hegemony of mathematics, to question the assumptions behind school mathematics, and to transform the curriculum into a more equitable one.

Making Use of the Perspectives to View Reform Initiatives

A review and synthesis of the literature concerning examples of equity-based reforms revealed that conceptually, these reforms fell into three categories: changing students, changing the learning environment and changing the curriculum. These categories loosely corresponded with the first three Willis (1996) perspectives respectively, the Remedial, the Non-Discriminatory and the Inclusive. There were few initiatives that exemplified the Socially Critical perspective. In this section, examples from the literature are presented along with how these examples are linked to the Willis framework. Also included is a discussion of how the use of the framework allows different aspects of inequity to be identified and dealt with.

Reforms trying to change students have focused on increasing enjoyment of and achievement in mathematics (Campbell, 1995; Keynes, 1995; Sanders, 1993; Stage, Kreinberg, Eccles, & Becker, 1985), raising awareness of the importance of mathematics (Campbell, 1995; Fennema, et al., 1981), and enhancing mathematics-related attitudes and affect (Clewell, Anderson, & Thorpe, 1992; Kenway & Willis, 1993; Thompson, 1995). Although many of these types of reforms have seen the problem as one of deficit in the student—reduced enjoyment of mathematics, poor awareness of the importance of mathematics, poor attitudes towards mathematics—this remedial perspective allows the focus to be on students. Focusing on students enables gaps in background knowledge or poor attitudes towards mathematics to be identified and corrected. When students lack confidence, activities that help build confidence can be designed so that students experience success without sacrificing standards. When students have poor attitudes towards mathematics, positive attitudes can be fostered by helping students to see the relevance and importance of mathematics to their everyday lives. Students can be informed about the importance of mathematics as a pre-requisite to many career options and provided with information about mathematics-related careers, thus enhancing student motivation to succeed.

Reforms trying to change the learning environment typically come from a non-discriminatory perspective, and are focused on improving teachers' content knowledge, pedagogy and assessment practices so as to provide a more equitable education for all their students (Banks, 1995; Clewell, et al., 1992; Ladson-Billings, 1995; Rogers, 1990; Rogers, 1995; Silver, Smith, & Nelson, 1995; Swafford, Jones, & Thornton, 1995; The Math Connection, 1993). Segregating males and females in single-sex classes is another non-discriminatory perspective reform that has been tried (Parker & Rennie, 1995; Rowe, 1988; Smith, 1986) and found to be helpful to those females who were less confident or suffered a great deal of harassment in the mixed-sex classroom (Parker & Rennie, 1995).

Focusing the view on teaching and assessment practices places the responsibility for creating an equitable classroom environment with the teacher. An equitable teacher is one that is able to recognise and act on inequities in their classroom environment. Having this skill relies on being informed about how to recognise inequity, and being informed goes back to initial teacher training, or in-service education. Areas that have received attention in the literature are assessment techniques, listening to and valuing student responses, actively involving students in learning, dealing with males who dominate classes, and having high expectations of students.

Much research has shown that certain assessment techniques are biased against females (Bolger & Kellaghan, 1990; Murphy, 1988; Murphy, 1996; Parker, 1992a; Parker & Tims, 1995; Rennie & Parker, 1991). Teachers must be informed of these possibilities, and empowered to act accordingly. Using a variety of assessment techniques is more equitable than using only one method of assessment.

Creating an equitable classroom environment necessitates teachers being able to listen to and actively involve students in the learning process. The traditional classroom scenario of the teacher as the knowledge provider, and the student the passive receiver does not allow the development of "student voice". Baxter Magolda (1992) described "student voice" as the ability to speak up for oneself, an attribute she noted was essential in enabling students "to evaluate knowledge critically, assess biased perspectives, analyse complex situations and make wise choices" (p. 391). The equitable teacher also values the contributions of every student and never belittles them.

The equitable teacher is also aware of the differential power structures within their classroom. For example, they are able to identify which students dominate the lesson and demand most of their time. Research has shown that males dominate many aspects of most classrooms (Leder, 1990b), and teachers must be able to recognise and compensate for this.

The final aspect of teacher behaviour that is crucial to the equitable classroom is the setting of high standards for students. In their portrait of a connected teacher, Belenky, Clinchy, Golberger and Tarule (1986) described the teacher as "rigorous". Related to this is how teacher expectations are linked to student achievement. It has long been known from research that teacher expectations are positively related to student achievement [See for example the meta-analysis of Smith (1980)]. Thus, as emphasised by Ladson-Billings (1995) setting high standards and having high expectations of students are now regarded as essential elements of achieving the equity pedagogy which underpins the equitable classroom.

Reforms trying to change the curriculum are typically from the Inclusive perspective, which focuses the view on aspects of the written curriculum. Inclusive reforms in mathematics have usually concentrated on making written curriculum documents more inclusive of the experiences of all students (Barnes & Coupland, 1990; Willis, 1995). However, there are also structural features of the curriculum which can contribute to inequity (Johnston, Rennie, & Offer, 1993), and which could also be the focus for Inclusive curriculum reform. There are certain crucial elements the curriculum must contain in order for equity to be achieved. First, the curriculum needs to value the culture and background experiences of all learners through the use of non-stereotypical language in texts and through using contexts that are inclusive of the range of contemporary students' experiences. The contributions of women and minorities to the history of mathematics need to be acknowledged. Viewing the curriculum from the inclusive perspective also makes it appropriate to discuss with students why the contributions of women and minorities have been ignored by the mainstream for so long.

The socially critical perspective focuses the view of the curriculum on issues of power, and how the traditional mathematics curriculum appears to have acted exclusively to the benefit of white males. Exposing the myth that mathematics is only for a select group of people can enable students to use mathematics to challenge social conditions. World problems of poverty, health, ecology, population and the distribution of wealth can be used as contexts in mathematics, as these are the problems students of today will increasingly be faced with in the future. Tate (1995) cites the example of students in an urban area in the USA researching about and acting on the illegal liquor outlets near their school. The teacher concerned had the freedom to set her own curriculum and allow her students to solve a problem, through the use of mathematics, which had personal meaning and relevance to them.

Using the Willis (1996) perspectives has enabled an overview of an equitable mathematics curriculum to be distilled from the literature. The two reforms that provide the specific context for this study will be related to the Willis perspectives in the next section.

THE SPECIFIC CONTEXT FOR THIS STUDY

The Western Australian Reform

The curriculum renewal in Western Australia has been fully reported on elsewhere (Parker, 1992b; Parker, 1995; Parker, et al., 1993; Parker & Thomson, 1993). What follows is a summary of the reform and subsequent monitoring projects.

In Western Australia, a structural curriculum change was implemented in senior-secondary mathematics Year 11 in 1991 and Year 12 in 1992. This new curriculum, incorporating the first major changes in nearly 15 years, was a clear break from the traditional content and approach of the previous curriculum. The stated aims of the curriculum renewal were to

- provide a more flexible structure for students' upper secondary school mathematics education;
- provide a structure which encourages all students to study the most challenging mathematics courses of which they are capable;
- cater better in terms of needs, abilities and aspirations for the more diverse group of students now in upper secondary school;
- provide more relevant mathematics courses, reflecting appropriately up-to-date content and current methodologies;
- encourage skills in the use of computers and calculators.

The intention of the new curriculum was different in content, design and methodology to that which it replaced. The placement and treatment of topics, although similar in content to the previous curriculum, was quite different. The structural reform allowed students to study Calculus by enrolling in just one unit of mathematics in Year 11; whereas in the previous structure, Calculus was only offered as part of a two-unit course. The effect of this structural change was to vastly increase the numbers of both males and females enrolling in Calculus, although the increase was greatest for females. Clearly, the motivation for the structural change was coming from the Remedial perspective, which suggests that solving problems of access will make outcomes equitable.

Along with this structural change, there was an expectation, by some of those involved with the reform, that the new content would encourage teachers to employ more gender-inclusive teaching strategies such as co-operative learning and activity-based problem solving in their classrooms. This expectation was coming from those with a Non-discriminatory perspective, but was never made explicit in the documentation provided to teachers. Although there was some professional development provided in the year before the implementation of the new curriculum, these sessions tended to concentrate on updating content knowledge, with only a small focus on new teaching strategies intended to accompany the changes. Assessment support was provided in the first year in the form of printed material containing exemplary assessment items for a small selection of content as well as a sample end-of-year examination paper.

Monitoring the Reform.

Monitoring of the reformed Western Australian mathematics curriculum commenced in the first year of implementation, 1991. The monitoring project collected a wide range of data from numerous sources. Quantitative data consisted of enrolment and achievement data made available by the State authority responsible for certification, the Secondary Education Authority (SEA). Qualitative data were collected from four case-study schools, interviews with key people involved in designing or implementing the new curriculum, and input from a "Reference Group" with representatives from key interest groups involved in the implementation.

The Ohio Reform

In 1990, the National Science Foundation (NSF) funded 10 Statewide Systemic Initiatives (SSIs), the overarching goal of which was to promote excellence in science and mathematics education through systemic reform. The SSI program eventually expanded to 24 states and Puerto Rico. Ohio's SSI, known as *Project Discovery*, focused on improving learning for all students through professional development of teachers. The specific goals of *Discovery* were to

- initiate validated professional-development models designed to build a critical mass of teachers who are knowledgeable in content and skilled in equitable and exemplary instructional practices;
- develop an infrastructure to support these models and teachers;
- act as a catalyst for the lasting systemic reform of teaching and learning of science and mathematics.

The initial summer institutes in mathematics, life science, and physical science were offered to teachers across the state in the summer of 1992 and were aimed at grades five through nine. Middle grades were chosen as the focus because it is during these years that students are set in a track for high school (Silver, et al., 1995).

The institutes were modelled on the successful course *Physics by Inquiry* developed at the University of Washington (Physics Education Group, 1990). Conducted for six weeks during the summer, these institutes were content based and set in an inquiry mode. The instructors modelled inquiry teaching, Socratic questioning and alternative-assessment techniques throughout the institute. Teacher participants learned mathematics, physics, and life science content by inquiry during the summer. Teachers also had to commit to participate in follow-up, academic-year workshops that focused on improving pedagogical knowledge. Follow-up and feedback on progress occurred through classroom visits from academic leadership teams comprised of trained teacher leaders and university educators. The establishment of an electronic bulletin board discussion group, along with the organisation of an annual *Discovery* Conference, provided participants opportunities for communicating with other teachers who were part of the SSI to discuss ideas about implementing the strategies provided in the summer institutes and follow-ups. Over the first four years of operation, 1,545 teachers in 85 of Ohio's 88 counties participated in professional development programs.

Project Discovery was far more closely aligned with the Willis (1996) Non-discriminatory perspective, placing the responsibility for creating an equitable curriculum with the teacher. Providing in-service education and support for teachers trying to effect this change was the clear focus of *Project Discovery* from its inception.

Monitoring the reform

In January 1995, the SSI initiated a study to assess the status of mathematics education in Ohio (Kahle & Rogg, 1995). Although only schools that had had teachers involved in the summer institutes (SSI teachers) were eligible to participate, both SSI and Non-SSI teachers were included in the study. In order to gain a broad understanding of the many factors influencing the success of this reform effort, many data sources were considered essential, encompassing both qualitative and quantitative types. The first major component of the design of the study was teacher-based: a questionnaire given to teachers in a random sample of schools across the state of Ohio. The second component was student-based: an achievement test, called the Mathematics Discovery Inquiry Test (MDIT), and

student questionnaire given to some students in selected schools. This test, based on public release NAEP items, had been constructed by a group of mathematics educators involved with the SSI, and was designed to assess problem solving and inquiry skills. The third component was classroom-based: site visits to a number of carefully selected sites to fill in the detail of the broad-brush picture obtained from the quantitative data.

FINDINGS OF THE REFORM MONITORING PROJECTS

While the structural reform in Western Australia had resulted in many more females having access to calculus in Year 11, there was little evidence of any wide-scale adoption of new teaching strategies.

In contrast, in the Ohio reform, results from the teacher questionnaire indicated that teachers who had participated in the SSI reported significantly higher frequencies of occurrence of teaching and assessment behaviours that could be considered gender-inclusive than teachers who had not participated (Kahle & Rogg, 1995). Achievement data from the MDIT indicated that, while students in classes taught by SSI teachers outperformed students in classes taught by non-SSI teachers, gender and ethnic differences were in the traditional directions: males significantly outperformed females and White students significantly outperformed African American students (Tims Goodell, Kelly, & Damnjanovic, 1997). However, it was clear that some changes to teaching practices had occurred in SSI classrooms, and that these changes were beginning to impact on students. When disaggregated data were considered, African American females demonstrated significantly improved performance in SSI classes as compared to Non-SSI classes. All other groups demonstrated improved performance in SSI classes, but not significantly. The gap between African Americans and Whites was beginning to close, and more quickly for females.

A number of barriers to implementation of gender-inclusive teaching strategies were identified by the evaluation in Western Australia. These were to do with assessment, time, and professional development. Teachers perceived little value in adopting new strategies when the State-wide high-stakes assessment and moderation procedures focused on traditional outcomes. Teachers were concerned about completing the course in the required time, and perceived that these new strategies were more time consuming to prepare and use in the classroom. Professional development was more concerned with content issues, with little time for or commitment to consideration of exactly how to create a gender-inclusive environment.

In Ohio, the major barrier to the adoption of more inclusive teaching strategies appeared to be the influence of the State-wide mandated Proficiency Test, which is multiple-choice and tests mostly basic skills. Students must pass this test in order to graduate from high school, and school districts and superintendents often place considerable pressure on teachers to "teach the proficiencies" and give practice tests for up to one month before the tests occur—usually in March, about three-quarters of the way through the academic year. Because of the structure of the Ohio academic year, students return from Christmas vacation in early January, and almost immediately start preparing for these tests. Many school districts also administer their own district-wide tests around the same time, effectively constraining teaching until April (there is also a one week vacation sometime near Easter).

DISCUSSION AND SYNTHESIS

In trying to understand the potential implications of the outcomes of both of these reforms, the ideas of Rossman (1993) are useful. Rossman described a conceptual framework for synthesising case studies located within the practice of systemic reform. The four dimensions of this framework are

Technical:	Professional knowledge and skills, and the means by which they are acquired.
Political:	Matters of authority, power and influence, including the negotiation and resolution of conflicts.
Cultural:	Values, beliefs and school norms—both in terms of a general ethos and competing perspectives that contend with each other.
Moral:	Matters of justice and fairness.

The technical dimensions encountered in the monitoring of the reforms concern the need for teachers to continue to update their content and pedagogical knowledge and to have access to resources which support the new pedagogy and assessment practices. Both reforms reported on here were centred on improving teachers' content knowledge, but only in Ohio did the reform provide a large degree of pedagogical support as well. Changes in teaching practices were evident in Ohio, but not in Western Australia. In addition, it was clear that teachers, particularly in Western Australia, had not been given sufficient information about equity research.

In relation to resources, teachers in both states were concerned with the lack of appropriate (inclusive) teaching materials. In particular, materials needed to use relevant real-world contexts that appealed to and had relevance for the diversity of students in the class.

Cultural issues which appeared were concerned with establishing and maintaining teacher networks, providing adequate follow-up support in the years following the reform, and making equity a professional issue across the whole school, all of which can also be seen as technical issues. Hargreaves (1994) clearly demonstrated the crucial role the professional culture of teaching plays in the reform process. Many teachers in Ohio commented that the electronic bulletin board, to which they all had access after the summer institutes, was a crucial link to other teachers experiencing the same joys and frustrations of implementation as they were. In Western Australia, the professional association of mathematics teachers, the Mathematical Association of Western Australia (MAWA), took on a much higher profile role in the mathematics education community during and after the implementation of the new curriculum by becoming a major provider of professional development opportunities for teachers. Professional associations can play a crucial role in the process of changing the culture of teaching so that teachers are more accepting of and more for change. Creating a collaborative culture occurred in the Ohio reform with university mathematics educators invited to participate in the summer institutes as assistant instructors and participants. For many of these people, this was the first experience of learning by inquiry. The links established here also ensured continuing support for the project from these people, and had the added benefit that the goals of the project were far more likely to be incorporated into university mathematics education courses in the future, thus assisting the project to become truly "systemic".

Another cultural issue was that of how to change the culture of mathematics teachers, especially older teachers who had seen many previous reforms fail, so that they would accept the new strategies suggested in the reform. In the Western Australian reform, new strategies were not adopted, essentially because they had not been mandated in the documentation provided to teachers. This could have been because authorities were not prepared to mandate strategies that may have been seen by some teachers to be less rigorous than traditional teaching strategies, and therefore should not be mandated. In Ohio, participation in the reform was voluntary except in a few instances. Tims (Goodell) and Brooks-Hedstrom (1996) monitored one such project within the Ohio reform where participation was compulsory, and teacher resistance to change was a major hurdle to overcome in the initial stages. However, after a whole year of professional development activities, the most experienced (and most resistant)

teacher was beginning to accept that there may be some merit in the ideas being presented.

Political issues, which surfaced in both states, concerned the power of assessment to influence classroom practices. In Ohio, further significant changes to teaching practices seem unlikely while the Proficiency Test continues in its current format as a multiple-choice skills-based test. In Western Australia, teachers continued to mimic the style and format of the State-wide high-stakes examination in their continuous assessment. Tims (Goodell) and Parker (1994) showed that even though assessment requirements for some of the new courses allowed a range of 25 - 50% of assessment using non-traditional items, most teachers used the minimum, with some using below the prescribed minimum.

Another issue concerning power and authority was that of support for the proposed changes from the school's principal. In Western Australia, the change to a new curriculum was mandated by State authorities, and principals had no choice but to support it. The limited amount of professional development provided to teachers was not a big strain on professional development budgets, and most teachers who wanted to attend the sessions were able to. In Ohio however, the reforms were not mandatory, and teachers had to convince their principal to support their application and approve six days of time release in the following academic year to attend the follow-up sessions. In one instance, at a school where we conducted a case study, the teacher who was the focus of our study had been applying for two years prior to her actual participation in the summer programme. The year she was finally supported was the same year that a new superintendent had joined the district. This superintendent had been involved with *Project Discovery* in an advisory capacity for a few years, and was extremely supportive of its aims. The teacher was sure that the timing of the new-found support of the principal was no coincidence.

For the above analysis we initially tried to categorise the issues identified through our research under only one of the four dimensions. As shown in our discussion however, many of the issues intersected or overlapped more than one dimension. We found that in reality, there are technical dimensions in most of the issues we identified as either cultural, political or moral.

IMPLICATIONS FOR PRACTICE

The above analysis has some important implications for practice in mathematics education.

Technical concerns raised the issue of ensuring that reform efforts include specific research findings as well as recommendations as to how these findings may be applied in the classroom. Without information about the potential bias of

certain testing procedures and the potential inclusivity of certain pedagogical techniques, along with the ability how to recognise inequity in their classroom, teachers were not equipped to begin making their classroom equitable.

The issue of provision of resources has a moral dimension. It is one thing to mandate reform, but quite another to ensure that sufficient money is allocated to provide the necessary resources to support the change. One solution is to provide, as part of the professional development accompanying the reform, training for teachers in evaluating current materials in terms of their inclusiveness. This training could also encompass how to modify existing materials to make them inclusive, and how to use such materials in the classroom.

A further moral aspect is that reforms can no longer continue to "blame the victim" and concentrate efforts for change only on students or teachers. The "system" must assume some blame as well. In mathematics education, the "system" is the curriculum, which, through its traditional male view of the world, privileges white males over all others (Willis, 1996). The curriculum must change, as it began to in Western Australia, so as to include the experiences and interests of all students, not just the privileged few.

An aspect that is moral and technical concerns providing an harassment-free environment. This aspect was of particular concern in the Western Australian reform. Clearly, from a moral standpoint, students of all ages need to feel secure that their contributions in class will not be ridiculed. They should feel free to offer their opinions, ask for assistance and respond to questions. From a cultural standpoint, the issue is how to change the culture of students (and the whole society) so that harassment is defined as unacceptable. There are obvious moves in that direction with legislation to protect people from harassment in the work place, but the fact that there has to be legislation indicates how entrenched harassment is in western society. It is only when laws of this type are no longer needed that an harassment free society may exist. Teachers can do their part in their own classrooms by ensuring that behaviour of this type is not tolerated. This raises a technical dimension, namely how to provide teachers with the knowledge and skills to combat harassment.

Reform efforts must consider how to involve professional associations in the reform process. An example of this occurred in Western Australia, where a new curriculum was trialed from 1994 to 1996 (Education Department of Western Australia, 1996). Funding was provided to interested consortia by the Australian government for professional development for teachers involved in the trial. One of the major criteria of eligibility for funding was that the consortium had to comprise partners from at least two areas of the education sector such as

universities, professional associations and education departments. This collaboration ensured continuing support for the reform from a range of stake holders.

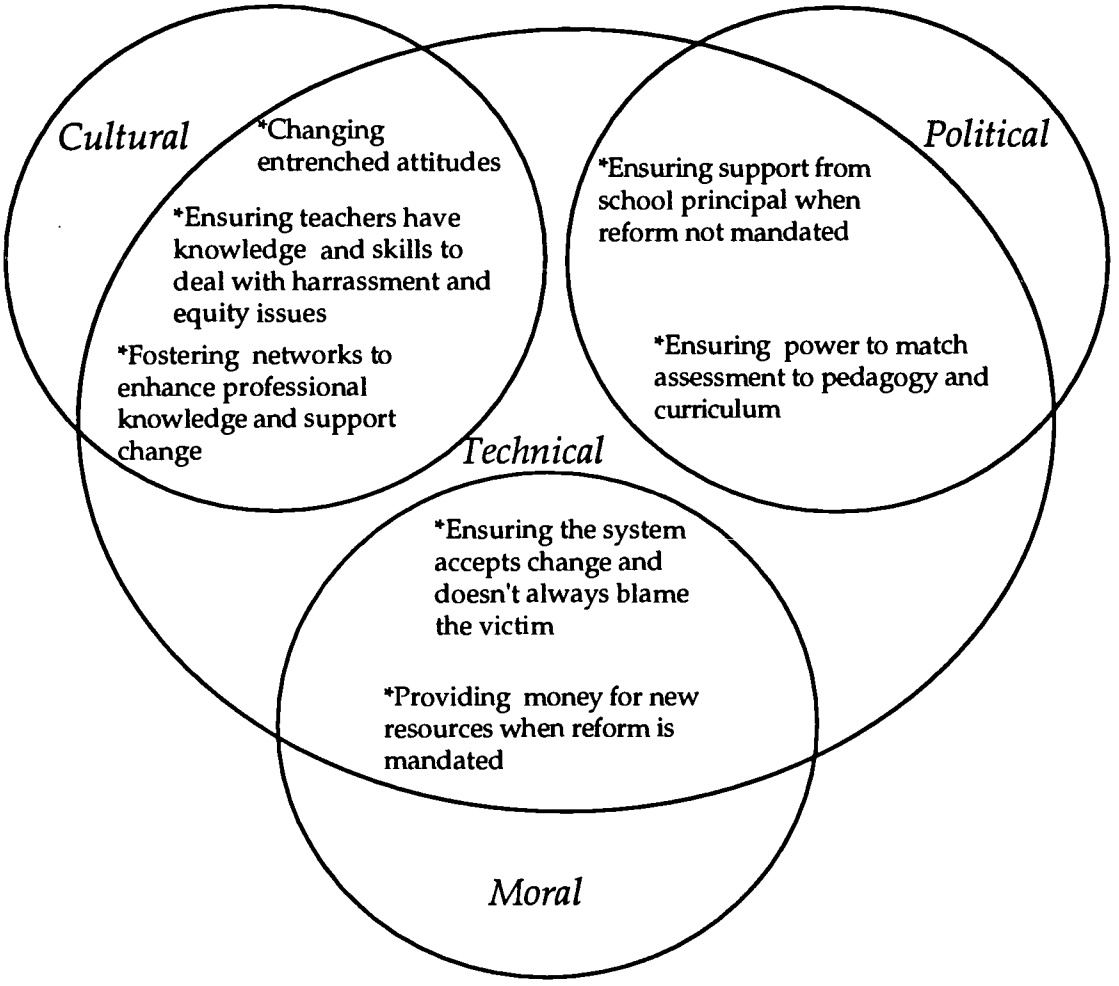
Changing the culture of teachers is a particularly hard feat to accomplish. Research has shown that change is slow, and experienced professional teachers will not throw out their old ideas in favour of new ones unless there is just cause to do so. Reform efforts must be able to justify, through presentation of relevant research findings, why change is necessary and desirable.

EQUITY CONSIDERATIONS FOR REFORM EFFORTS

Our research has shown that consideration of the cultural, political and moral dimensions of reform are as important in the reform process as providing teachers with appropriate pedagogical and content knowledge. Often these technical aspects of reform are the only "visible" aspects of the reform process. We have re-conceptualised the four dimensions into imperatives that must be taken into account by reform efforts that have equity goals. This model is shown in Figure 1

Figure 1

Synthesis of concerns for equity-based reform



Further research will be required to test the applicability of this model, derived from a mathematics education context, to other contexts.

The objective of this paper was to examine the links between equity and mathematics education reform. We showed, through an analysis and synthesis of findings from the monitoring of two State-wide reforms in mathematics education, that, unless certain crucial aspects from the four dimensions suggested by Rossman (1993), (the Technical, Cultural, Moral, and Political), are carefully considered and acted upon, the goals of equity may well be lost in reform. Our synthesis of concerns raised by our monitoring of large-scale reform projects will hopefully provide guidance to those involved in the process of educational reform.

REFERENCES

American Association of University Women (1992). *How schools shortchange girls*. Washington, DC: American Association of University Women Educational Foundation.

Australia. Department of Employment Education and Training (DEET) (1991). *National database on the education of girls in Australian schools: 1987 and 1988*. Canberra: Australian Government Publishing Service.

Banks, J. A. (1995). Multicultural education: Historical development, dimensions, and practice. In J. A. Banks (Eds.), *Handbook of Research on Multicultural Education* (pp. 3-24). New York: Macmillan Publishing USA Simon & Schuster Macmillan.

Barnes, M., & Coupland, M. (1990). Humanizing calculus: A case study in curriculum development. In L. Burton (Eds.), *Gender and mathematics: An international perspective* (pp. 72-80). London: Cassell.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college - Gender related patterns in students' intellectual development*. San Francisco: Jossey-Bass Publishers.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bolger, N., & Kellaghan, T. (1990). Method of measurement and gender differences in scholastic achievement. *Journal of Educational Measurement, 27*(2), 165-174.

Burton, L. (1992). Who assesses whom and to what purpose? In M. Stephens & J. Izard (Eds.), *Reshaping assessment practices: Assessment in the mathematical sciences under challenge* (pp. 1-18). Hawthorn, Vic: Australian Council for Educational Research.

Burton, L. (1995). Moving towards a feminist epistemology of mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 209-225). London: The Falmer Press.

Campbell, P. B. (1995). Redefining the "girl problem in mathematics". In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 225-241). Cambridge: Cambridge University Press.

Clewell, B. C., Anderson, B., & Thorpe, M. E. (1992). *Breaking the barriers: Helping female and minority students succeed in mathematics and science*. San Francisco: Jossey-Bass Publishers.

Clewell, B. C., & Ginorio, A. B. (1996). Examining women's progress in the sciences from the perspective of diversity. In C.-S. Davis, A. B. Ginorio, C. S.

Hollenshead, B. B. Lazarus, P. M. Rayman, & Associates (Eds.), *The equity equation: Fostering the advancement of women in the sciences, mathematics, and engineering* (pp. 163-231). San Francisco: Jossey Bass.

Dekkers, J., deLaeter, J. R., & Malone, J. A. (1991). *Upper secondary school science and mathematics enrolment patterns in Australia, 1970-1989*. Perth, WA: National Key Centre for School Science and Mathematics, Curtin University of Technology.

Eccles, J. S. (1989). Bringing young women to math and science. In M. Crawford & G. Gentry (Eds.), *Gender and thought: Psychological perspectives* (pp. 36-58). New York: Springer-Verlag.

Education Department of Western Australia (1996). *Report of the Student Outcome Statements trial: Mathematics report*. Perth, WA: Author.

Equity in Mathematics Education (1990). *Summary of a study of participation, performance, gender and ethnic differences in mathematics in New Zealand secondary schools and first year university courses*. Wellington: Victoria University of Wellington.

Fennema, E. (1990). Justice, equity and mathematics education. In E. Fennema & G. C. Leder (Eds.), *Mathematics and gender* (pp. 1-9). New York: Teachers College Press.

Fennema, E., Wolleat, P. L., Pedro, J. D., & Becker, A. D. (1981). Increasing women's participation in mathematics: An intervention study. *Journal for Research in Mathematics Education, 12*(1), 3-14.

Frost, L. A., Hyde, J. S., & Fennema, E. (1994). Gender, mathematics performance and mathematics-related attitudes and affect: A meta-analytic synthesis. *International Journal of Educational Research, 21*, 373-385.

Gaskell, P. J., McLaren, A., Oberg, A., & Eyre, L. (1993). *The 1990 British Columbia mathematics assessment: Gender issues in student choices in mathematics and science*. Victoria, BC: Ministry of Education and Ministry Responsible for Multiculturalism and Human Rights.

Grevholm, B. (1996). Women's participation in mathematics education in Sweden. In G. Hanna (Eds.), *Towards gender equity in mathematics education* (pp. 9-26). Dordrect: Kluwer Academic Publishers.

Hargreaves, A. (1994). *Changing teachers, changing times*. London: Cassell.

Husen, T. (1967). *International study of achievement in mathematics*. New York: John Wiley & Sons.

Johnston, J. E., Rennie, L. J., & Offer, J. A. (1993). Structural change in curriculum: The implications for equitable participation and achievement in mathematics. *Curriculum Perspectives, 13*(1), 1-7.

Kahle, J. B., & Rogg, S. R. (1995). *A pocket panorama of the Landscape Study*. Oxford, OH: Miami University.

Kenway, J., & Modra, H. (1992). Feminist pedagogy and emancipatory possibilities. In C. Luke & J. Gore (Eds.), *Feminisms and critical pedagogy* (pp. 138-166). New York: Routledge.

Kenway, J., & Willis, S. (1993). Back to the future for girls and schools. In D. L. Smith (Eds.), *Australian curriculum reform: Action and reaction* (pp. 51-61). Canberra, ACT: Australian Curriculum Studies Association.

Keynes, H. B. (1995). Can equity thrive in a culture of mathematical excellence? In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 57-92). Cambridge: Cambridge University Press.

Ladson-Billings, G. (1995). Making mathematics meaningful in multicultural contexts. In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 126-145). Cambridge: Cambridge University Press.

Leder, G. (1990a). Gender differences in mathematics: an overview. In E. Fennema & G. C. Leder (Eds.), *Mathematics and gender* (pp. 10-26). New York: Teachers College Press.

Leder, G. C. (1990b). Teacher/student interactions in the mathematics classroom: a different perspective. In E. Fennema & G. C. Leder (Eds.), *Mathematics and gender* (pp. 149-168). New York: Teachers College Press.

Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Eds.), *Handbook of research on mathematics teaching and learning* (pp. 597-622). New York: Macmillan.

Linn, M. C., & Hyde, J. S. (1989). Gender, mathematics, and science. *Educational Researcher, 18*(8), 17-27.

Linn, M. C., & Kessel, C. (1995). *Participation in mathematics courses and careers: Climate, grades, and entrance examination scores.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Murphy, P. (1988). Gender and assessment. *Curriculum, 9*, 165-171.

Murphy, P. F. (1996). Assessment practices and gender in science. In L. Parker, L. Rennie, & B. Fraser (Eds.), *Gender, science and mathematics: Shortening the shadow* (pp. 105-117). Dordrecht: Kluwer Academic Publishers.

Niederdrenk-Felgner, C. (1996). Gender and mathematics education: a German view. In G. Hanna (Eds.), *Towards gender equity in mathematics education* (pp. 9-26). Dordrect: Kluwer Academic Publishers.

Parker, L. (1992a). Sex differences in performance on external examinations and school-based assessment in science subjects. In *Annual Conference of the Western Australian Science Education Association (WASEA),* . Perth, Western Australia: Ministry of Education.

Parker, L. H. (1992b). *Curriculum renewal in upper secondary mathematics in Western Australia: A preliminary evaluation.* Perth, Western Australia: Key Centre for School Science and Mathematics, Curtin University of Technology.

Parker, L. H. (1995).*Curriculum renewal in upper secondary mathematics: the limits and possibilities of reform. Keynote.* In Annual Conference of the New Zealand Association of Mathematics Teachers Auckland, New Zealand:

Parker, L. H., & Rennie, L. J. (1995). *For the sake of the girls? Final report of the Western Australian single-sex education pilot project: 1993-1994.* Perth, Western Australia: National Key Centre for Teaching and Research in School Science and Mathematics, Curtin University of Technology.

Parker, L. H., Thomson, K., & Tims, J. E. (1993). *Curriculum renewal in upper secondary mathematics in Western Australia: The second year.* Perth, Western Australia: Key Centre for School Science and Mathematics, Curtin University of Technology.

Parker, L. H., & Thomson, K. J. (1993). *Gender and mathematics: Limits and possibilities of structural curriculum change.* Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

Parker, L. H., & Tims, J. E. (1995). *Different modes of assessment in science and mathematics: A systematic interaction with gender.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco.

Physics Education Group (1990). *Physics by Inquiry.* Seattle: University of Washington.

Rennie, L. J., & Parker, L. H. (1991). Assessment of learning in science: The need to look closely at item characteristics. *Australian Science Teachers Journal, 37*(4), 56-59.

Robitaille, D. F., & Garden, R. A. (1989). *The IEA study of mathematics II: Contexts and outcomes of school mathematics.* Oxford: Pergamon Press.

Rogers, P. (1990). Thoughts on power and pedagogy. In L. Burton (Eds.), *Gender and mathematics: An international perspective* (pp. 38-46). London: Cassell.

Rogers, P. (1995). Putting theory into practice. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 175-185). London: The Falmer Press.

Rossman, G. (1993). *Building explanations across case studies: A framework for synthesis*. Boulder, CO: Colorado University School of Education.

Rowe, K. J. (1988). Single-sex and mixed-sex classes: The effects of class type on student achievement, confidence and participation in mathematics. *Australian Journal of Education, 32*(2), 180-202.

Sanders, J. (1993). A large American project that got thousands of girls into mathematics, science and technology. In S. Haggerty & A. Holmes (Ed.), *Contributions - GASAT 7 International Conference. Transforming Science and Technology: Our Future Depends On It,* (pp. 110-117). Canada: The University of Waterloo Ontario Canada.

Silver, E. A., Smith, M. S., & Nelson, B. S. (1995). The QUASAR project: Equity concerns meet mathematics education reform in the middle school. In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 9-56). Cambridge: Cambridge University Press.

Smith, M. (1980). Meta-analysis of research on teacher expectation. *Evaluation in Education, 4*, 53-55.

Smith, S. (1986). *Separate tables? An investigation into single-sex setting mathematics*. London: Her Majesty's Stationary Office.

Stage, E., Kreinberg, N., Eccles, J., & Becker, J. R. (1985). Increasing the participation and achievement of girls and women in mathematics, science, and engineering. In S. S. Klein (Eds.), *Handbook for achieving sex equity through education* (pp. 237-268). Baltimore, MD: John Hopkins University Press.

Swafford, J. O., Jones, G., & Thornton, C. A. (1995). *Changing middle grades teachers' classroom practices*. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Tate, W. F. (1995). Returning to the root: A culturally relevant approach to mathematics pedagogy. *Theory Into Practice, 34*(3), 166-173.

The Math Connection (1993). *Creating a climate for change: Math leads the way*. WQED Pittsburg.

Thompson, D. T. (1995). The METRO achievement program: Helping inner city girls excel. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 27-36). London: The Falmer Press.

Tims Goodell, J. E., Kelly, M. K., & Damnjanovic, A. (1997). *Classroom factors associated with systemic reform in science and mathematics education*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Chicago, IL.

Tims, J. E., & Brooks Hedstrom, M. (1996). *Teacher change in a mandatory district wide professional development program*. Paper presented at the Annual

Meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Tims, J. E., & Parker, L. H. (1994). *Changing assessment practices in upper secondary mathematics in Western Australia.* Paper presented at the Annual Conference of the Australian Association for Research in Education, Newcastle, NSW.

Willis, S. (1995). Gender reform through school mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 186-199). London: The Falmer Press.

Willis, S. (1996). Gender justice and the mathematics curriculum: Four perspectives. In L. H. Parker, L. J. Rennie, & B. J. Fraser (Eds.), *Gender, science and mathematics: Shortening the shadow* (pp. 41-51). Dordrecht: Kluwer Academic Publishers.

SE060251

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Operationalizing Equity Through School Reform in Mathematics.	
Author(s): ① Joanne E. Tims Goodell ② Lesley H Parker	
Corporate Source: CURIN UNIVERSITY OF TECHNOLOGY.	Publication Date: March 1997

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce the identified document, please CHECK ONE of the following options and sign the release below.

[X] ← Sample sticker to be affixed to document

Check here
Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 1

Sample sticker to be affixed to document → [ ]

or here
Permitting reproduction in other than paper copy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 2

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Signature: Joanne Tims Goodell	Position: PROJECT OFFICER
Printed Name: JOANNE TIMS GOODELL	Organization: TLG, CURTIN UNIVERSITY
Address: GPO BOX U1987 PERTH WA 6845 AUSTRALIA	Telephone Number: 61 9 351 2113
	Date: 21 April 1997

OVER